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First record and range extension of *Corbicula fluminea* (Müller, 1774) (Bivalvia, Cyrenidae) in the Chapada dos Veadeiros region, Goiás, Brazil

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Abstract

Corbicula fluminea (Müller, 1774) is an Asian freshwater clam that is widely distributed throughout the world through multiple introductions. Its invasion can cause environmental and economic damage. In Brazil, *C. fluminea* is recorded in all major hydrographic basins. Here, we report the first record of *C. fluminea* in the Chapada dos Veadeiros region of Goiás, Brazil. This new record extends the known distribution of this species to a conserved area in the Cerrado biome, towards areas of interest for conservation and integral protection units of the biodiversity.

Keywords

Central-Western Region, Cerrado, freshwater mollusk, invasive species

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Introduction

The Golden Clam, *Corbicula fluminea* (Müller, 1774) is a freshwater bivalve mollusk native to South and East Asia (southeastern Russia, Thailand, Philippines, China, Taiwan, Korea, and Japan). It is considered an alien invasive species (AIS) worldwide (Santos et al. 2012). Haag et al. (2020) found that *C. fluminea* can be a major factor in the decline of native populations of freshwater mussels worldwide. This is the most important AIS in the conservation perspective for riverine ecosystems due to its high invasive potential (Leal et al. 2021). The first known record of the introduction of this species was in North America in the 1930s and it has since become the dominant invasive mollusk in that country (Mayfield et al. 2021). Mitigation of the impacts caused by *C. fluminea* have cost 1 billion dollars in the United States of America (Mayfield et al. 2021). Although not known for Brazil, the economic costs have probably been similar.

The first introduction of *C. fluminea* into South America was in the 1960s in the La Plata Basin (Ituarte 1981), possibly via ballast water (Darrigran 2002; Paschoal et al. 2013). This species is currently widespread according to Darrigran et al (2020) and Miyahira et al. (2020). Since the first Brazilian record in the 1970s (Veitenheimer-Mendes 1981), *C. fluminea* has been reported in all major river basins. There are records of this species in the Upper Tocantins River in the state of Goiás

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(Thiengo et al. 2005) (Tocantins-Araguaia Basin); Tietê River in São Paulo (Suriani et al. 2007), Paranoá Lake in Distrito Federal (Rodrigues et al. 2007), Paranapanema River in São Paulo (Jorcin and Nogueira 2008), Araguari River in Minas Gerais (Maroneze et al. 2011), Toropi River in Rio Grande do Sul (Sá et al. 2013), Ivinhema River in Mato Grosso do Sul (Isaac et al. 2014), Upper Paraná River in Paraná (Ragonha et al. 2014), Jundiaí-Mirim River in São Paulo (Beghelli et al. 2014) (Paraná River Basin); São Francisco River in Sergipe (Santana et al. 2013) (São Francisco River Basin); Guandu River in Rio de Janeiro (Miyahira et al. 2017) (Paraíba do Sul River Basin); Cuiabá River in Mato Grosso (Fernandez et al. 2014) (Paraguai River Basin); and Negro River, Amazonas (Pimpão and Martins 2008) (Amazonas River Basin).

This species has been mainly associated with anthropized habitats (Miyahira et al. 2020) promoting environmental and biotic homogenization and facilitating the biological invasion of other taxonomic groups (Agostinho et al. 2008; Petsch 2016; Pigneur et al. 2014; Arantes et al. 2019). In the Tocantins-Araguaia Basin, this species was recorded in the municipalities of Niquelândia and Santa Rita do Novo Destino, Goiás state in an influenced by the Serra da Mesa Reservoir (Thiengo et al. 2005). There are no other records of this species in the region since then. Here, we extend the known occurrence of *C. fluminea* to the Chapada dos Veadeiros region of Goiás, Brazil.

Methods

The new record presented here was made during a study of the benthic fauna in which 14 sites were sampled in the Tocantinzinho, Couros, and São Bartolomeu rivers. All sampling sites are within the region known as Chapada dos Veadeiros, which is characterized by a plateau at elevations above 1,200 m. The Chapada dos Veadeiros region, in Goiás state, is within the Cerrado biome, near the center of the biome. All sampling sites in this study were in the Pouso Alto Environmental Protection Area (Pouso Alto EPA), which allows for sustainable use.

We sampled using a D-net for benthos in a 5 m × 2 m area with three replicates (totaling 10 m^2) each for 30 min. Physical features and chemistry of the water were measured, such as river depth and width, dissolved oxygen, turbidity, conductivity, and pH.

Results

We found 16 specimens of *Corbicula fluminea* (Fig. 1) at only one sampling site, in the Tocantinzinho River, Upper Tocantins River Basin (Fig. 2). The stretch of river in this sample area 50 m wide and had a depth of 1.5 m near the banks but the main river channel was deeper. The water was slightly acidic (pH 6.03). Dissolved oxygen was 11 mg/L, and the electrical conductivity was 46.4 mS. The margins in this site are natural and intact, as the riverbank is composed mainly of embedded rocks which make it difficult for people to access.

New record. BRAZIL – **Goiás**; Pouso Alto EPA, Chapada dos Veadeiros, Colinas do Sul municipality, −14.2580, −047.9838; 495 m a.s.l, Maria Julia Martins-Silva leg.; 7.VIII.2019; 16 individuals (14 living individuals and 2 shells), CMUnB 1359.

Identification. Our specimens conform to the descriptions by Mansur and Pereira (2006) for *C. fluminea*. The specimens had subtriangular shells with curved dorsal margin. The external shell surface has narrow, large and widely spaced concentric ribs over the entire surface. The periostracum varies from yellow (usually in young) to dark brown. The umbones are elevated and inflated. The internal shell color was light yellow.

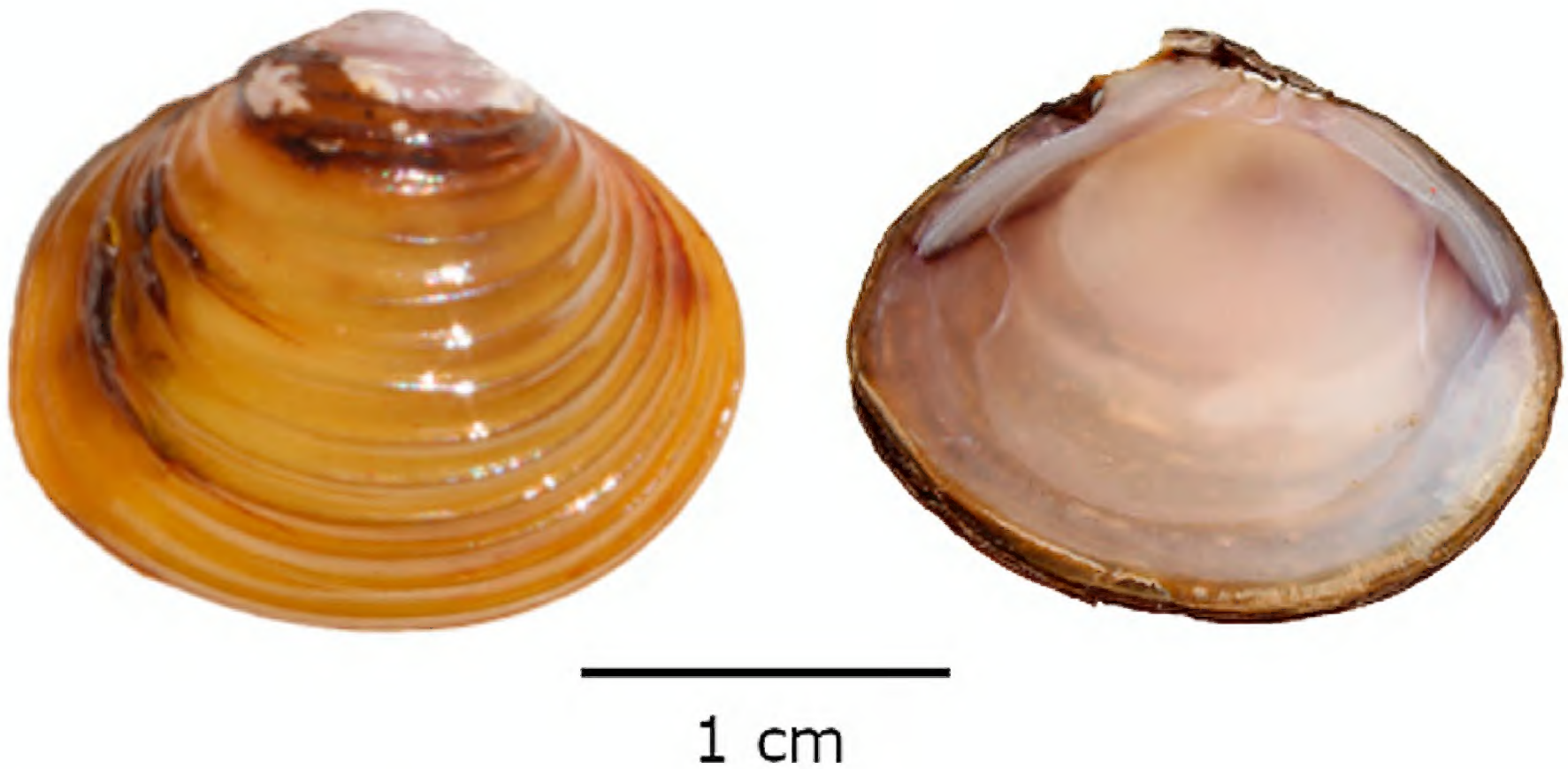

Figure 1. *Corbicula fluminea* collected at Chapada dos Veadeiros (CMUnB 1359), external and internal view.

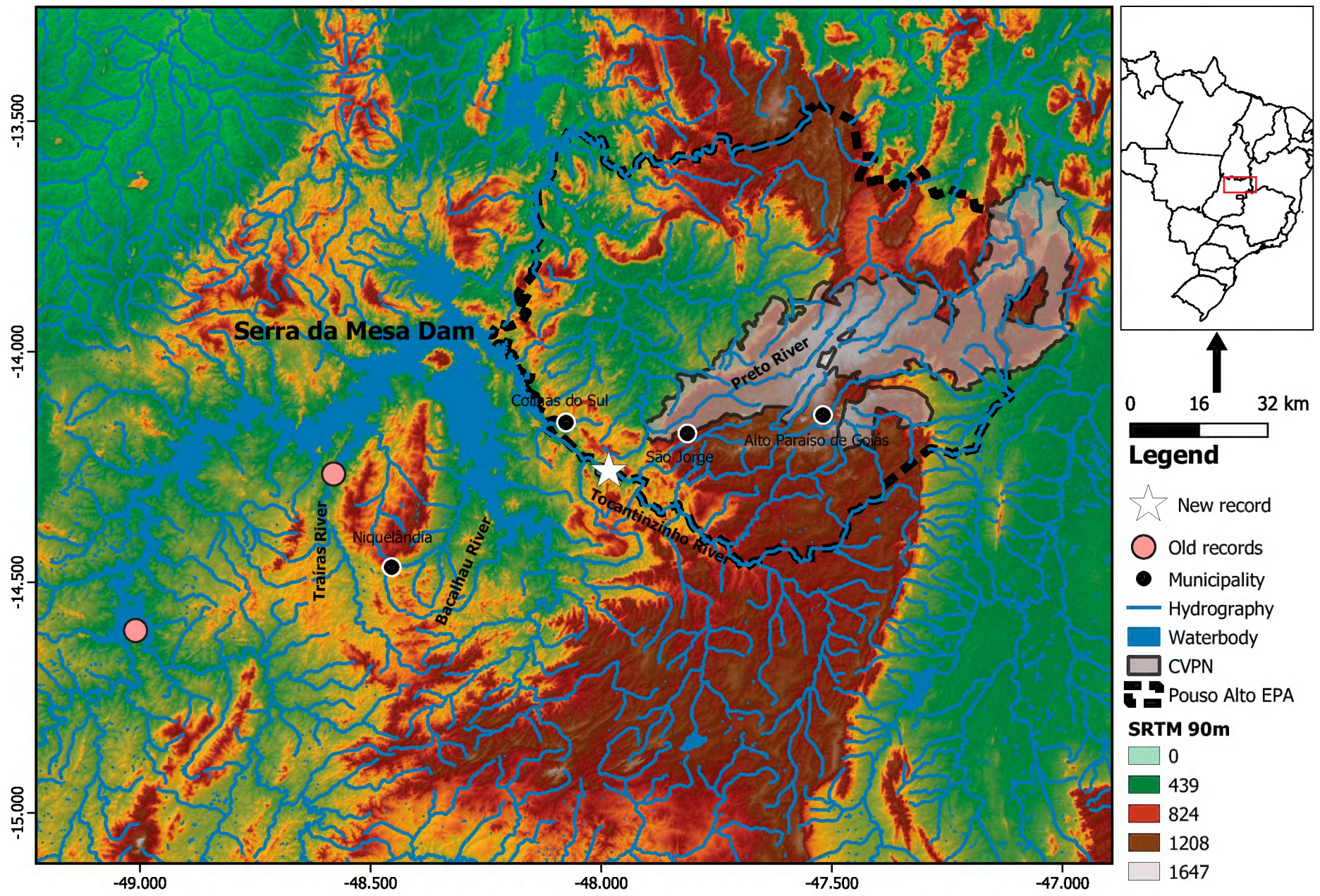

Figure 2. New record *Corbicula fluminea* (white star), previous records (pink circle) and municipality (black circle). Boundaries of the Chapada dos Veadeiros National Park (solid black line) and boundary of the Pouso Alto Environmental Protection Area (dashed black line).

Discussion

Here, we report a new record of *Corbicula fluminea* in the Tocantinzinho River. This new record represents the first of this invasive species from the Chapada dos Veadeiros region, in Colinas do Sul municipality, Goiás state. This region is within the Pouso Alto Environmental Protection Area near Chapada dos Veadeiros Nacional Park. This new record expands the distribution of *C. fluminea* by at least 200 km southeast of the first records of this species in the Basin of the Tocantinzinho River, which were mainly associated with the Serra da Mesa Reservoir (Thiengo et al. 2005). Previous records of this species are from the reservoir of the Serra da Mesa dam, which is formed by the confluence of the Maranhão, Almas, and Tocantinzinho rivers. However, none of these records include upstream portions of the Tocantinzinho River—stretches of the free river outside the area influenced by the Serra da Mesa dam. Our record is important because it shows that *C. fluminea* has expanded its occurrence into conserved areas of the Cerrado biome. Our new record of *C. fluminea* was made 15 years after the first sighting of this invasive species by Thiengo et al. (2005), which demonstrates that this species is established in the region.

Predictive models for the occurrence of *C. fluminea* have shown its a preference for shallow water and sandy substrates with little organic matter (Silveira et al. 2016). In the Tocantinzinho River, this species was found on shallow waters in the river. Linares et al. (2020) and Darrigran et al. (2020), demonstrated that the occurrence of this species is correlated with anthropogenic modifications. For example, the construction of dams is associated with multiple biological invasion processes that favor the occurrence of these molluscs, mainly by modifying the water body. However, our sampling site was quite preserved, and the specimens probably came from anthropized localities in downstream stretches within the same Basin. Invasive species, such as *C. fluminea* and *Melanoides tuberculata* (Müller, 1774), have repeatedly been associated with the construction of dams in Brazil (Franca et al. 2007; Miyahira et al. 2017; Linares et al. 2018, 2019, 2020; Branco et al. 2019). Recent studies have indicated that these species use reservoir as ecological steppingstones to spread to new sites (Johnson et al. 2008; Linares et al. 2018). In the Chapada dos Veadeiros region, the Serra da Mesa Reservoir act as source population for the dispersal of *C. fluminea* to other areas of the Basin, such as the Tocantizinho River. However, knowledge the dispersion capacity of *C. fluminea* is incipient, and more sampling is needed between the reservoir and at our site to be able to better explain the expansion of this species. Genetic studies would also be helpful in determining the linkage between the two sites.

Even so, two hypotheses are possible to explain the expansion of *C. fluminea* upstream of the Serra da Mesa reservoir. The first hypothesis is that the removal and transport of sand from rivers for construction may

be responsible for the dispersal of this species and may explain the gaps in its occurrence along the rivers (Belz et al. 2012; Sonia et al. 2012). The second is that this *C. fluminea* may pass through the digestive system of fish alive and be carried to new stretches of the river by fish movements; several species of invasive mollusks have been found in the last portion of the digestive tract of fish still alive, indicating a potential mechanism of dispersion for these organisms (Cantanhede et al. 2008; Isaac et al. 2014; Avila-Simas et al. 2019; Rosa et al. 2019; Darrigran et al. 2020; Gonzalez-Bergonzoni et al. 2020).

Our new record has relevant to conservation in Chapada dos Veadeiros region, the most preserved area in northeastern Goiás. We recommend that monitoring be carried out to better understand the demographics and the pattern of dispersal of C. fluminea upstream in the rivers as the São Miguel, Couros e Vãozinho, for example. These rivers have numerous stretches within areas of environmental protection.

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Authors' Contributions

Conceptualization: MJMS, YFFS. Data curation: MJMS. Formal Analysis: MJMS, YFFS. Funding acquisition: MJMS. Investigation: MJMS, YFFS. Methodology: MJMS. Project administration: MJMS. Resources: MJMS. Supervision: MJMS. Validation: MJMS. Visualization: MJMS, YFFS. Writing – original draft: MJMS, YFFS. Writing – review and editing: MJMS, YFFS.

References

Agostinho AA, Pelicice FM, Gomes LC (2008) Dams and the fish fauna of the Neotropical region: impacts and management related to diversity and fisheries. Brazilian Journal of Biology 68: 1119-1132. https://doi.org/10.1590/S1519-69842008000500019

Arantes CC, Fitzgerald DB, Hoeinghaus DJ, Winemiller KO (2019) Impacts of hydroelectric dams on fishes and fisheries in tropical rivers through the lens of functional traits. Current Opinion in Environmental Sustainability 37: 28–40. https://doi.org/10.1016/j.cosust.2019.04.009

Avila-Simas S, Morato MM, Reynalte-Tataje DA, Silveira HB, Zaniboni E, Normey-Rico JE (2019) Model-based predictive control for the regulation of the Golden Mussel *Limnoperna fortunei* (Dunker, 1857). Ecological Modelling 406: 84–97. https://doi.org/10.1016/j.ecolmodel.2019.05.010

Beghelli FGS, Pompêo MLM, Carlos VM (2014) First occurrence of the exotic Asian clam *Corbicula fluminea* (Müller, 1774) in the Jundiaí-Mirim river basin, SP, Brazil. Revista Ambiente & Água 9: 402–408. https://doi.org/10.4136/ambi-agua.1330

Belz CE, Darrigran G, Netto OSM, Boeger WA, Ribeiro Junior PJ (2012) Analysis of four dispersion vectors in inland waters: the case of the invading bivalves in South America. Journal of Shellfish Research 31 (3): 777–784. https://doi.org/10.2983/035.031.0322

Branco CWC, Leal JJF, Huszar VLD, Farias DD, Saint'Pierre TD, Sousa IF, de Palermo EFD, Guarino AWS, Gomes AR, Kozlowsky-Suzuki B (2019) New lake in a changing world: the construction and filling of a small hydropower reservoir in the tropics (Rio de Janeiro, Brazil). Environmental Science and Pollution Research 26: 36007–36022. https://doi.org/10.1007/s11356-019-06665-y

Cantanhede G, Hahn NS, Gubiani EA, Fugi R (2008) Invasive molluscs in the diet of *Pterodoras granulosus* (Valenciennes, 1821) (Pisces, Doradidae) in the Upper Paraná River floodplain, Brazil. Ecology of Freshwater Fish 17: 47–53. https://doi.org/10.1111/j.1600-0633.2007.00258.x

Darrigran G (2002) Potential impact of filter-feeding invaders on temperate inland freshwater environments. Biological Invasions 4 (1): 145–156. https://doi.org/10.1023/A:1020521811416

Darrigran G, Agudo-Padrón I, Baez P, Belz C, Cardoso F, Carranza A, Collado G, Correoso M, Cuezzo, MG, Fabres A, Gregoric DEG, Letelier S, Ludwig S, Mansur MC, Pastorino G, Penchaszadeh P, Peralta C, Rebolledo A, Rumi A, Santos S, Thiengo S, Vidigal T, Damborenea C (2020) Non-native mollusks throughout South America: emergent patterns in an understudied continent. Biological Invasions 22: 853–871 https://doi.org/10.1007/s10530-019-02178-4

Fernandez MA, Mattos AC, Silva EF, Santos SB, Thiengo SC (2014) A malacological survey in the Manso Power Plant, state of Mato Grosso, Brazil: new records of freshwater snails, including transmitters of schistosomiasis and exotic species. Revista da Sociedade Brasileira de Medicina Tropical 47: 498–506. https://doi.org/10.1590/0037-8682-0138-2014

Franca RS, Suriani AL, Rocha O (2007) Species composition of benthic molluscs in the reservoirs of low Tiete River (São Paulo, Brazil) with an evaluation of the impact of exotic invader species. Revista Brasileira de Zoologia 24: 41–51. https://doi.org/10.1590/S0101-81752007000100005

Gonzalez-Bergonzoni I, Silva I, de Mello FT, D'Anatro A, Boccardi L, Stebniki S, Brugnoli E, Tesitore G, Vidal N, Naya DE (2020) Evaluating the role of predatory fish controlling the invasion of the Asian Golden Mussel *Limnoperna fortunei* in a subtropical river. Journal of Applied Ecology 57: 717–728. https://doi.org/10.1111/1365-2664.13573

Haag WR, Culp J, Drayer AN, McGregor MA, White DEJ, Price SJ (2020) Abundance of an invasive bivalve, *Corbicula fluminea*, is negatively related to growth of freshwater mussels in the wild. Freshwater Biology 66: 447–457. http://doi.org/10.1111/fwb.13651

Isaac A, Fernandes A, Ganassin MJM, Hahn NS (2014) Three invasive species occurring in the diets of fishes in a Neotropical floodplain. Brazilian Journal of Biology 74: 16–22. https://doi.org/10.1590/1519-6984.18312

Ituarte CF (1981) Primera noticia acerca de la introduccion de pelecipodos asiaticos en el area rioplatense. Neotropica 27: 79-82

Johnson PTJ, Olden JD, Vander Zanden MJ (2008) Dam invaders: impoundments facilitate biological invasions into freshwaters. Frontiers in Ecology and the Environment 6: 359–365. https://doi.org/10.1890/070156

Jorcin A, Nogueira MG (2008) Benthic macroinvertebrates in the Paranapanema reservoir cascade (southeast Brazil). Brazilian Journal of Biology 68: 1013–1024. https://doi.org/10.1590/S1519-69842008000500009

Leal MF, Simone LRL, Lacerda ACF, Silva EL, Pinheiro TG (2021) Current distribution of the invasive molluk *Corbicula fluminea* (O.F. Müller, 1774) (Bivalvia, Cyrenidae in Brazil, including a new record from the state of Piauí. Check List 17 (1): 151–157. https://doi.org/10.15560/17.1.151

Linares MS, Assis W, Solar RRD, Leitao RP, Hughes RM, Callisto M (2019) Small hydropower dam alters the taxonomic composition of benthic macroinvertebrate assemblages in a Neotropical

river. River Research and Applications 35: 725–735. https://doi.org/10.1002/rra.3442

Linares MS, Callisto M, Marques JC (2018) Thermodynamic based indicators illustrate how a run-of-river impoundment in Neotropical savanna attracts invasive species and alters the benthic macroinvertebrate assemblages' complexity. Ecological Indicators 88: 181–189. https://doi.org/10.1016/j.ecolind.2018.01.040

Linares MS, Macedo DR, Massara RL, Callisto M (2020) Why are they here? Local variables explain the distribution of invasive mollusk species in Neotropical hydropower reservoirs. Ecological Indicators 117: 106674. https://doi.org/10.1016/j.ecolind.2020.106674

Mansur MCD, Pereira D (2006). Bivalves límnicos da bacia do Rio dos Sinos, Rio Grande do Sul, Brasil (Bivalvia, Unionoida, Veneroida e Mytiloida). Revista Brasileira de Zoologia 24 (4): 1123–1147. https://doi.org/10.1590/S010-81750060004000021

Maroneze DM, Coscarelli D, Vidigal T, Callisto M (2011) First record of *Corbicula fluminea* (Müller, 1774) in the drainage basin of the Araguari River, Minas Gerais, Brazil. Brazilian Journal of Biology 71: 221–222. https://doi.org/10.1590/S1519-69842011000100033

Mayfield III AE, Seybold SJ, Haag WR, Johnson MT, Kerns BK, Kilgo JC, Larkin DJ, Lucardi RD, Moltzan BD, Pearson DE, Rothlisberger JD, Schardt JD, Schwartz MK, Young MK (2021) Impacts of invasive species in terrestrial and aquatic systems of united states. In: Poland TM, Patel-Weynand T, Finch DM, Miniat CF, Hayes DC, Lopez VM (Eds.) Invasive species in forests and rangelands of the United States. Springer Nature, Cham, Switzerland, 5–40. https://doi.org/10.1007/978-3-030-45367-1

Miyahira IC, Carneiro JB, Gonçalves ICB, Lacerda LEM, Oliveira JL, Vasconcelos MC, Santos SB (2017) Freshwater mollusks and environmental assessment of Guandu River, Rio de Janeiro, Brazil. Biota Neotropica 17: e20170342. https://doi.org/10.1590/1676-0611-bn-2017-0342

Miyahira IC, Pereira LS, Santos LN (2020) Non-native freshwater molluscs in the Neotropics: what can be learned from Brazilian reservoirs? Aquatic invasions 15 (3): 455–472. https://doi.org/10.3391/ai.2020.15.3.06

Paschoal LRP, Andrade DP, Darrigran G (2013) Size comparison of quadrats in sample of non-native bivalve *Corbicula fluminea* (Müller, 1774) (Bivalvia: Corbiculidae). Pan-American Journal of Aquatic Sciences 8 (4): 369–374.

Petsch DK (2016) Causes and consequences of biotic homogenization in freshwater ecosystems. International Review of Hydrobiology 101: 113–122. https://doi.org/10.1002/iroh.201601850

Pigneur LM, Falisse E, Roland K, Everbecq R, Deliège JF, Smitz JS, Doninck KV, Descy JP (2014) Impact of invasive Asian clams, *Corbicula* spp., on a large river ecosystem. Freshwater Biology 59: 573–583. https://doi.org/10.1111/fwb.12286

Pimpão DM, Martins DS (2008) Ocorrência do molusco asiático *Corbicula fluminea* (Müller, 1774) (Bivalvia, Corbiculidae) no baixo rio Negro, Amazônia central. Acta Amazonica 38: 589–591. http://dx.doi.org/10.1590/S0044-59672008000300026

Ragonha FH, Pinha GD, Petsch DK, Mansur MCD, Takeda AM (2014) First records of freshwater bivalves of Ilha Grande National Park, Paraná, Brazil. Iheringia 104: 14–20. https://doi.org/10.1590/1678-4766201410411420

Rodrigues JCA, Pires-Junior OR, Coutinho MF, Martins-Silva MJ (2007) First occurrence of the Asian *Corbicula fluminea* (Bivalvia: Corbiculidae) in the Paranoá Lake, Brasília, Brazil. Brazilian Journal of Biology 67: 789–790. https://doi.org/10.1590/S1519-69842007000400032

Rosa DM, Gaspar MRD, Silva FA, Pompeu PS (2019) Impacts of predation by Piapara *Megaleporinus obtusidens* (Valenciennes, 1837) on the population densities of the invasive Golden Mussel *Limnoperna fortunei* (Dunker, 1857). Biological Control 129: 158–163. https://doi.org/10.1016/j.biocontrol.2018.10.012

Sá RL, Santin L, Amaral AMB, Martello AR, Kotzian CB (2013) Diversity of mollusks in streams of a montane region in southern Brazil. Biota Neotropica 13: 213–221. https://doi.org/10.1590/S1676-06032013000300024

Santana DO, Martins-Silva MJ, Bocchiglieri A, Pantaleão SM, Faria RG, Souza BB, Rocha SM, Lima LFO (2013) Mollusca, Bivalvia, Corbiculidae, *Corbicula fluminea* (Müller, 1774): first record for the Caatinga biome, northeastern. Check List 9 (5): 1072–1074. https://doi.org/10.15560/9.5.1072

Silveira TCL, Gama AMS, Alves TP, Fontoura NF (2016) Modeling habitat suitability of the invasive clam *Corbicula fluminea* in a Neotropical shallow lagoon, southern Brazil. Brazilian Journal of Biology 76: 718–725. https://doi.org/10.1590/1519-6984.01915

Sonia SB, Thiengo SC, Fernandez MA, Miyahira IC, Gonçalves ICB, Ximenes RF, Mansur MCD, Pereira P (2012) Espécies de moluscos límnicos invasores no Brasil. In: Mansur MCD, Santos CP, Pereira D, Paz ICP, Zurita MLL, Rodriguez MTR, Nehrke MV, Bergonci PEA (Eds.) Moluscos límnicos invasores no Brasil: biologia, prevenção e controle. Redes Editora, Porto Alegre, Brazil, 25–49.

Suriani AL, Franca RS, Rocha O (2007) Benthic malacofauna of the reservoirs of the middle River Tietê (São Paulo, Brazil) and an ecological evaluation of the invading exotic species, *Melanoides tuberculata* (Müller) and *Corbicula fluminea* (Müller). Revista Brasileira de Zoologia 24: 21–32. https://doi.org/10.1590/S0101-81752007000100003

Thiengo SC, Santos SB, Fernandez MA (2005) Malacofauna límnica da área de influência do lago da usina hidrelétrica de Serra da Mesa, Goiás, Brasil. I. Estudo qualitativo. Revista Brasileira de Zoologia 22: 867–874. https://doi.org/10.1590/S0101-81752005000400010

Veitenheimer-Mendes IL (1981) *Corbicula manilensis*, (Philippi, 1844) molusco asiático, na bacia do Jacuí e do Guaíba, Rio Grande do Sul, Brasil (Bivalvia, Corbiculidae). Iheringia 60: 63–74.